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ABSTRACT

An investigation-based course on teaching strategies for in-service science and mathematics teachers has been developed. The purpose of this course was to learn how to teach science or mathematics from the constructivist perspective. The course development was based on constructivism, especially social constructivism. Major adjustments concerning the structure, contents, and the ways of teaching have been made on this course. The course not only introduced constructivism, but taught according to its principles, letting the teachers construct their teaching knowledge by doing (cooperative problem solving), talking (sharing information and ideas), and writing (journals, reports). Furthermore, the course also had the teachers investigate their own teaching problems. During investigation the teachers have experienced problem searching, planning, and executing action research. Teachers' learnings were illustrated by excerpts from their journals. A follow up assessment of this course was reported also. (Author)

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Development of a Course on Instructional Strategies for In-service Science and Mathematics Teachers

by
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Abstract

An investigation-based course on teaching strategies for in-service science and mathematics teachers has been developed. The purpose of this course was to learn how to teach science or mathematics from the constructivist perspective. The course development was based on constructivism, especially social constructivism. Major adjustments concerning the structure, contents, and the ways of teaching have been made on this course. The course not only introduced constructivism, but taught according to its principles, letting the teachers construct their teaching knowledge by doing (cooperative problem solving), talking (sharing information and ideas), and writing (journals, reports). Furthermore, the course also had the teachers investigate their own teaching problems. During investigation the teachers have experienced problem searching, planning, and executing action research. Teachers' learnings were illustrated by excerpts from their journals. A follow up assessment of this course was reported also.

Introduction

In Taiwan, traditional curricula for in-service teachers in continuing education were formal-training oriented, having teachers study advanced professional subjects and science/mathematics education subjects, and usually learning these courses in the traditional way -- by listening. Help for the teachers to improve their teaching by this method was limited. Many teachers complained they were not able to use their newly-learned skills in their own classrooms. To realize the actual goal of enhancing the skills of teachers, an investigation-based course on instruction strategies was developed . This course gained positive responses from the majority of the teachers who participated. This article reports on the development of this course.

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Radical Constructivism and Social Constructivism

Radical constructivism (von Glaserfeld, 1995) and social constructivism (Ernest, 1991) were the guiding concepts of this course. Social constructivism views knowledge as a social construction. Radical constructivism views knowledge existing only within the mind, therefore being extremely subjective. Books contain no knowledge at all, only symbols and signs. This system (knowledge in books) is very different from the knowledge in human brains. Strictly speaking, objective knowledge as we know it is not knowledge. "Objective" is understood to be "social" in order to possess meaning (Ernest, 1991). Objective knowledge, recipes, are nothing more than a profound mess of words and numbers to those who do not understand the meaning within. To those who are learned in the art of cooking, recipes may represent delicacies. Traditionally, teaching is very much like teaching recipes to students and depriving them of the actual experience of cooking. In the end, students learn these recipes but do not know how to cook. In this case, the pupils doubt the use of these recipes since they have had neither the experience of cooking nor a chance to taste even a bite of such dishes.

Social constructivism links subjective knowledge and objective knowledge in a creative cycle in which each contributes to the renewal of the other (Ernest, 1991). In this cycle, new objective knowledge originates from personal subjective knowledge, and via publication becomes objective knowledge. New subjective knowledge comes from personal experience and the learning of science and mathematics. Knowledge is formed by an endless, evolutionary cycle of subjective and objective knowledge. So the knowledge of cooking includes actual experience (subjective) and the recipe (objective). The personal subjective knowledge of cooking is presented as a recipe, and learning the recipe forms (internalized and reconstructed by individuals) one's new subjective knowledge of cooking. Thus, subjective and objective knowledge of cooking each contributes to the creation and re-creation of the other. Thus, the art of cooking and recipes are the process of an ever improving evolution. From this perspective, knowledge is ever growing and changing (Nickson, 1992).

Knowledge often comes from problem solving (Freudenthal, 1971), hence, constructing knowledge by solving problems is an effective strategy. Problem-centered learning is not only effective for mathematics but also for other subjects as well (Wheatley, 1989,1991). Therefore, the problem-

centered learning model was the key model for the teachers to learn through this course.

Problem-centered Learning

The traditional courses for in-service teachers usually introduce the theories before giving an example and then finally allowing the teachers to practice. If constructivism were introduced in a traditional way, it would not have the desired effect of improving the teachers ability to teach. From the constructivist perspective, the teachers construct constructivism by themselves, based on their experience of constructing knowledge. Realizing the spirit of constructivism in the teachings of constructivism itself is therefore a great challenge to this new course. Basically, the course takes the approach of the problem-centered learning model. Under this approach, the teachers had a great deal of opportunity to clarify the goals of teaching science or mathematics, the nature of the subject, learning, and teaching. The discussions of these problems reappeared in different units or different modes of approach were used, for example, starting the class with a questionnaire, having participants reflect and warm up, then starting small group discussions. Afterwards, the teams reached an agreement through social interaction. Then each team representative shared the report with the entire class. The instructor directed the whole- class discussion in order to reach a consensus.

After class, the teachers communicated with the instructor by means of writing journals. Finally, the teachers re-reflect on their activity on the nature of knowledge, learning, and teaching problems by writing a final report. In this way, the teachers construct constructivism and teaching strategies based on the knowledge and experience already within their grasp.

Classroom Activity

Instead of introducing constructivism at the beginning of the session, the participants are given the following problems:

(1) What is the purpose of teaching science or mathematics?

(2) What is knowledge (math or science)?

(3) What is learning?

During a 30 to 50-minute, small-group discussion, the teachers had chance to discover or formulate their own teaching problems. Then 50 minutes were allotted for each group representative to share their ideas

with the whole class. During the whole class discussion, the instructor introduced some important concepts, such as the goals of mathematics education in America (NCTM, 1989, 1991), Britain (Orton & Wain, 1994), Holland (Lange Jzn, 1987), and Taiwan. Many teachers suddenly realized at this time that they had never considered the goal or objectives of teaching science or mathematics, focusing instead on the textbook schedule, test scores, and class discipline. Many teachers felt ashamed of their own teaching in the past.

After a small-group discussion of the meaning of "knowledge" and "learning," the instructor directed the whole-class discussion. During the whole-class discussion, the instructor guided the teachers to construct some important concepts, such as empiricism, rationalism, constructivism (Nussbaum, 1989), radical constructivism (von Glaserfeld, 1991), and social constructivism(Ernest, 1991).

Teachers' Reflections on the Problem-centered Learning Activity

During a problem-centered learning class, participants worked together in teams, in this way former knowledge was reorganized and new knowledge constructed. The following are four excerpts from journals written by some in-service teachers during the course. From this viewpoint, problem-centered learning allowed the teachers to experience constructing knowledge for themselves.

> During today's class, I really experienced the interaction between teaching and learning, especially the concepts of "doing, discoursing, presenting, writing," even breaking from the traditional, one-way learning mode -- "listening." The methods used by the instructor in the class not only accomplished the goals of teaching, but also allowed us to practice with the theory of constructivism ourselves. This enabled us to construct knowledge, and understand the strategy and theory of social constructivism much better than the traditional "telling."

> The contents of the course have rarely been encountered in the past. It is new but a rather heavy burden because the learning model is different from the past. Before, I passively waited for the teacher to give knowledge. Any problems encountered were referred to the teacher to solve. At present, the instructor gives

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the problems, leaving the answers to be thought out, explored, and solved by ourselves, but there is always more than one answer, making it more uncertain. I hope to shift my learning style from passive to active by taking this course.

Today's small-group tasks are: How to teach in order to reflect the following characteristics of students:

1.large differences between individuals;

2.refusal to learn;

3.lacking advanced thinking abilities and skills.

During the discussion, every member of the group gradually developed new viewpoints apart from their originally naive and intuitive views of the problem. In the past, there was no chance to discuss these viewpoints with other group members. These viewpoints were ever emerging within the mind but little thought was given to them. I don't know if anybody has thought of this problem or not. If they did, what were their thoughts? During the discussion I heard the concepts of the others. This was an unprecedented experience. It matters not whether the problem is solved or not, but that intense thought has been given to the problem. After listening to the reports of the other members of other groups, I felt the impact again. Actually, there was so many other viewpoints. This entire class session gave me the inspiration that learning can occur this way.

In the beginning, things were very different from my expectations: I had originally decided to copy word-for-word anything written on the blackboard, and then study at home. Before my eyes was the group discussion of my classmates. They were devotionally sharing their viewpoints and thoughts. The instructor guided us properly and provided suggestions. During this process I was surprised by the superb performance of my classmates. Never before had I thought of these viewpoints, opinions I could not, or dared not, express. ... I realized the amazing effects of small group discussions. ... The impression I received from this method of teaching is that the teachers were rather relaxed in this way and we could also learn what we were supposed to learn.

Constructing Knowledge Based on One's Experiences

After many sessions on different topics such as the problems of science or mathematics education in Taiwan, the aims of science or mathematics teaching, and the nature of science or mathematics, everybody had already acquired the experience of problem-centered instruction. The teachers had experienced the creation of knowledge and meanings on different topics. During the discourse and presentation and sharing experience, everyone had also personally gone through social construction by negotiation in order to reach an agreement on one's own experience. After the participants had already experienced constructing knowledge, we spoke of constructivism. When most participants had gone through problem-centered learning, we discussed the model of problem-centered learning. When the participants had a problem or were confused by this learning model, we discussed how to revise the problem-centered model.

The core course was basically compatible with the claims of the new course, that is, learning by doing, understanding by discoursing, and mastering by writing. Thus, the new course helped teachers to change their methods and to adapt them to social constructivism. So, these participants were learning in this way also. From the reactions and weekly journal of the participants, we could see they were constructing their knowledge (concepts, methods, skills, and strategies) of teaching in satisfying ways.

Improving Teaching By Doing Investigation

These participants solved their own teaching problems in classroom through small investigation; by writing midterm and final reports, they were doing medium investigation. The new course was designed to be investigation-based with participants learning by investigating. They constructed their own teaching strategies by doing action research. They developed their teaching ability by finding and solving their own teaching problems.

Journal, Reflection and Communication

Reflection and communication are the two main elements in constructing knowledge. Reflection and communication in the classroom need to be extended in order for the teachers to have a chance to continue to reflect and the chance to communicate with the instructor. The

instructor requests the teachers to write journals (Waywood, 1992) every class session and turn them in by next week in class. After the instructor reviews these journals, they are returned the next week and some of these are shared with the entire class, and questions raised in the journals are discussed. These questions or problems sometimes become the problem for the teachers to discuss or to investigate.

The following were some of the problems raised in the journals:

1. Knowledge is for explaining experience. However, junior high school students have not had much experience yet. Before they have experience, how can they possibly have the motive to find knowledge for explaining experience?
2. What are the ways for devising proper problems, guiding group discussion for students, and receiving expected teaching results.
3. If students construct differently from us, what should the teachers do?
4. Constructive teaching is the minority in [the] school [where I am teaching], how do I hold on to my own ideals and opinions?
5. In high school biology courses, about genetic control mechanisms for example, if the teacher does not tell the students beforehand, how can the students construct this concept?
6. Would guiding students in constructing knowledge reverse the identities of the student and the teacher?
7. Isn't repetition another effective way for slow learners?

In the journal writing, the in-service teachers got the chance to reflect on their own teaching situations and problems. The following was a teacher's reflection in his journals.

> Having been teaching for many years, I had always felt that students have become more and more stupid, forgetting after being taught, doing many problems but still not understanding. The more I taught, the more tired I was. Now I understand, that the problem comes from myself; no matter how hard I try, traditional teaching methods are useless, a waste of energy.

Journals are a very good avenue for communication between the instructor and the teachers. By reviewing the teachers' journals, the instructor could evaluate the learning situation, problems, and need for

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encouragement and correction of the teachers. The teachers could relate previous knowledge and experience by writing the journal, reviewing and reflecting on the knowledge learned in class.

Weekly evaluation of the journal can provide feedback to the teachers and provide the instructor references for evaluation and improvements of the course. In the journal, the teachers' thoughts and problems can be further discussed and shared in the classroom, promoting communication between the teachers themselves, and also between the teachers and the instructor.

After experiencing problem-centered learning, most teachers consider practicing it in their own class. However, teaching is complicated and has many variables; however, solving problems triggered by changing teaching strategies is the greatest challenge to adjusting the teaching methods of the teachers. If the teacher can not solve the problems caused by changing teaching strategies, the teacher will eventually return to traditional "telling" teaching.

Evaluating of the Course by Follow Up

Forty-four in-service teachers (male 32, female 9; Junior high 35, Senior high 6; math 7, science 25, biology 9) joined 1995 summer program of continuing education. Most of them had been teaching for 6-12 years. This course was two credits, 36 hours, two sessions a week for 6 weeks, 3 hours for each session. After the 6-week intensive course, over 90% of the subjects said that they would use the problem-centered learning model in their classroom teaching.

One year later, 41 teachers returned to the summer program for second-year curriculum. Based on the analysis of the teachers' action research reports: "My Teaching Last Year," the results could be divided into five groups:

Group 1. 4 (9%) didn't use,

Group 2. 11 (27%) tried a little,

Group 3. 9 (22%) selected easy units to do,

Group 4. 9 (22%) changed the model,

Group 5. 8 (20%) used problem-centered learning model successfully in their classroom teaching.

The reasons each group took different approaches in their teaching varied:

Group 1. The teachers were not enough confident to try it.

Group 2. The teachers could not solve the problem raised by using the problem-centered learning model. They then returned to the traditional teaching.

Group 3. They chose the units and the classes that were easy to teach using the model.

Group 4. They changed the model. For example, they used whole-class discussion instead of small-group, mixing traditional teaching and problem-centered learning.

Group 5. They solved their teaching problem actively and focused on issue related problems. For example, they tried to analyzed the tasks, guidance, environment of their teaching, and improved by doing action research.

Conclusions

If we want teachers to teach from the constructivist perspective, we must teach them in the same way. The development of this course was based on constructivism, especially social constructivism. Problem-centered learning and the investigative approach were two elements of this course. The purpose of this course was to learn how to teach science and mathematics from the constructivist perspective.

Teaching is complicated and it is difficult to predict events that occur. It is nearly impossible to prepare the teaching activities for each teacher in advance. Needless to say, teachers' knowledge, abilities, and interests are not the same. Thus, the most important thing is for teachers to develop their own teaching ability, meaning teachers explore, identify, and evaluate their own teaching problems, and plan and design action research to solve these problems. In this way, the teachers' ability would develop to a more professional level.

Knowing and doing are two different matters. Teachers are incapable of understanding to what extent they understand constructivism and whether their teaching strategies are compatible with constructivism. Due to the lack of experience and understanding, these teachers bump into problems they cannot solve when actually using the constructivist approach in the classroom. In-service teachers need to develop their teaching ability by continually exploring and conducting action research based on constructivism. Developing teaching ability is the goal of this course.

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